

Results From Automatic Equipment Identification Testing

by

Thomas S. Guins, Paul Kromberg
and Thomas W. Taylor

TD 94-006

Summary

To support the industry's AEI application plan and standard, the Research and Test Department sponsored a series of performance tests at its Transportation Test Center to resolve questions about the characteristics and performance limits of the adopted AEI technology.

The issues addressed by the testing included the following:

- ◆ Vertical tag placement limitations
- ◆ Proximity limitations of multiple tags and multiple tag types
- ◆ Suitability of the specified tag placement window for specialized intermodal equipment
- ◆ Performance comparison of different tag generations [versions].

The tests resulted in the following major conclusions:

- ◆ Tags on railcars and locomotives may be placed as high as 5'6" above top-of-rail, provided those above 5' are angled downward at a 20-degree angle.
- ◆ Typical intermodal antenna site arrangements can reliably read most intermodal equipment tags at all speeds specified by the AEI Standard, i.e., up to 80 miles per hour.
- ◆ Required minimum separation between tags varies considerably by tag type.
- ◆ Different tag generations ["Version 1" and "Version 2"] perform with no difference in readability.
- ◆ Ambient noise and/or vibration adversely affects tag readability.

The findings of these tests have resulted in several modifications and additions to the AAR Mechanical Division Standard for AEI (S-918).



Association of American Railroads
Research and Test Department



INTRODUCTION AND CONCLUSIONS

In 1989, the AAR issued a voluntary automatic equipment identification standard for use on railcars, locomotives, end-of-train devices, trailers, containers, and chassis. This standard specifies tag electronic characteristics, placement, and data content.

The specified technology uses passive radio-frequency tags for railcars and locomotives, and tags that require batteries for other equipment. The tags modulate and reflect back to wayside readers information about the equipment on which they are placed, using the 902-928 MHz band. The encoded data includes initial and number, and selected other data that varies with the type of equipment. Two tags are placed on each railcar and locomotive [on opposite corners], and one tag is used for other equipment.

In 1991, to improve the industry's capabilities to provide reliable, cost-effective service, the industry adopted a plan to tag the entire interchange fleets of railcars, locomotive, and end-of-train devices by January 1, 1995.

As the industry's AEI implementation plan for rail equipment progressed, and interest in intermodal tagging increased, some of the AEI system characteristics and performance limits remained unknown. To address these unknowns, the Research and Test Department sponsored a series of tests at its Transportation Test Center. Tests were conducted using typical AEI antenna arrays consisting of parapanel antennas 3.5 feet above-top-of-rail (ATOR) and 12 feet from the center of the track and log periodic antennas located at top-of-rail and 7.5 feet from the center of the track for the wayside readers.

Following are the test issues and conclusions:

◆ Vertical tag placement limitations:

Due to the design of some freight cars [particularly covered hoppers], finding a location to readily place tags in the specified tag placement window could be difficult. Tests were conducted to determine whether tags could be mounted higher than the five feet above top of rail maximum currently specified.

The tests revealed that tags on railcars and locomotives may be placed as high as 5'6" above top-of-rail, provided they are angled downward at a 20-degree angle.

◆ Proximity limitations of multiple tags and multiple tag types:

As users began to increase AEI applications [e.g., chassis tagging], questions arose regarding how close multiple tags and tag types could be placed to the standard tag.

The test results proved that the required separation between tags varies considerably by tag type (see Figure 1).

◆ Suitability of the specified tag placement window for specialized intermodal equipment:

Tag placement had not been thoroughly addressed in the original AEI standard for equipment such as chassis, flat rack containers, and refrigerator generator sets.

The testing indicated that typical intermodal antenna site arrangements can reliably read most intermodal equipment tags.

◆ Performance comparison of different tag versions: Railroads asked whether there was a difference in read performance of different tag versions.

The tests revealed that the tags performed with no difference in readability.

◆ Effect of ambient noise and/or vibration on tags' readability.

While the testing did not seek to address this issue, results demonstrated that ambient noise and/or vibration adversely affects tag readability.

The findings of these tests have resulted in several modifications and additions to the AAR Mechanical Division Standard for AEI (S-918). Specifically, these changes include allowance for higher vertical placement of tags, providing they are angled downward, and a major reworking of tag placement specifications for chassis and specialized intermodal equipment.

VERTICAL TAG PLACEMENT LIMITATIONS

To maximize both readability and tag installation flexibility, the industry sought to determine the maximum height at which tags could be installed before system performance would be adversely affected. The existing AEI Standard specified a maximum height of 5' above top-of-rail.



The tests used the worst case condition, a low-mounted antenna at top-of-rail, 7' 8" from the centerline of the track. The tests determined that tags can be reliably read as high as 5' 6" if they are tilted downward at an angle of 20 to 30-degrees. Tags so placed can be read as well as tags located at five feet ATOR with no downward tilt.

TAG SEPARATION TESTS

As the AEI program progressed, it became clear that in some cases, more tags than specified by the basic AEI system would be desired. For example, some roads began to use dynamic tags, which can relay changing, real time information, to monitor fuel levels on locomotives. Thus, testing was performed to determine the minimum horizontal and vertical separation that is required between a standard tag and each of the various tag types. The testing also considered the polarization [orientation] of each tag. These tests were conducted using a typical antenna array.

These tests used standard tags designated as control tags, polarized horizontally, five feet above top-of-rail. The testing varied the horizontal and vertical distances and polarizations between the control tags and different test tags. The resulting minimum separations in feet between the control (standard) tag and other tags are shown in Figure 1. As an example, the minimum separation between the control (standard) tag and a horizontal intermodal (battery) tag was 16 feet.

| TAG TEST | TAG | | | | | | |
|---------------------------------|-----|----|----|----|----|----|----|
| | HS | VS | HI | HD | VI | VD | HE |
| HORIZONTAL SEPARATION (in. ft.) | 15 | 1 | 16 | 3 | 15 | 1 | 16 |
| VERTICAL SEPARATION (in. ft.) | 2.5 | 1 | 4 | 1 | 4 | 3 | 4 |

Figure 1. Separation Tests

Note: H=Horizontal, V=Vertical, S=Standard, I=Intermodal, D=Dynamic, E=EOT

INTERMODAL EQUIPMENT TAGS

As interest in intermodal tagging increased, testing was required to determine optimal tag placement specifications for intermodal equipment other than ordinary trailers and containers. Therefore, we tested the relative readability of tags in alternative locations.

The test site consisted of an arrangement of antennas typically found at intermodal AEI locations. The site consisted of a parapanel and two log periodic antennas ["intermodal antennas"] on each side of the track. The parapanel antenna reads the railcar and chassis tags, and the log periodics each read one level of stacked containers or a trailer.

CHASSIS TAGS

The AEI Standard specifies that chassis tags are placed on the right front bolster. This testing determined that, in some circumstances, the parapanel antenna cannot reliably read tags in this location. Specifically, the tags cannot reliably be read when:

- ◆ One 45' chassis is directly behind another on an 89' flatcar.
- ◆ Bolsters have indented spaces in the tag placement area.
- ◆ Two 45' chassis on adjacent 89' flatcars are nose to nose. The two tags interfere with each other.

However, when a Yagi antenna was mounted specifically to read these tags, it could do so reliably.

When the tags are placed forward of the landing leg oriented at a 45-degree angle facing forward and to the right, the parapanel antenna could read reliably. The parapanel antenna should also read tags reliably if they are placed on the right corner of the bolster at a 45-degree angle. However, this antenna did not read the tags tested in this position, but that is attributed to the use of end-of-train device tags rather than intermodal tags in the test. EOT tags have a shorter reading range than intermodal tags.

FLAT RACK CONTAINERS

Flat rack containers are containers with no top or sides. Some have fixed or folding bulkheads. The existing tag location standard did not address this type of equipment.



Tags located on the bulkhead [in an upright position] could be read reliably by the lower log periodic antenna. Tags located on the bulkhead [in the collapsed position] could be read reliably by the parapanel antenna.

Tags located on the side of the flat rack container with horizontal polarization could also be read reliably by the parapanel antenna. However, horizontally polarized tags interfere with railcar tags if they are positioned 16 feet or less from the railcar tags.

REFRIGERATION EQUIPMENT

Testing was also performed for tags mounted on generator sets and nitrogen clips (used in the newer cryogenically cooled containers) that are typically attached to containers or trailers, and separable refrigeration units.

The testing determined that a tag mounted vertically on the right side of a front-mounted refrigeration unit interferes with the container's intermodal tag. A horizontal tag mounted on the right side of a front-mounted refrigeration unit does not interfere with the container's intermodal tag, but requires an additional horizontally polarized antenna to read that tag. However, the appropriate intermodal antenna can reliably read a tag mounted vertically on the left side of a front-mounted refrigeration unit.

Parapanel antennas should also read tags placed on underslung refrigeration units, at a 45-degree angle. These tags are in a similar location to that tested for chassis that could be read.

SOFT-SIDED TRAILERS/CONTAINERS

Soft-sided equipment has fabric sides that provide no metal surface on which to mount tags. The intermodal antennas can reliably read tags on this equipment if the tags are attached to metal backing plates at least as large as the tag and placed in the same location as specified for other trailers/containers. The backing plates provide a reflective metal surface required for reliable tag reading.

READABILITY OF DIFFERENT TAG GENERATIONS

Testing was performed to determine whether any performance difference exists between "Version 1" and "Version 2" tags. "Version 2" tags were developed as a modification to the previous tag to resist high levels of radio-frequency energy, as had been experienced from a radar site near Amarillo, TX.

The testing indicated no difference in readability between the two tag designs.

EFFECT OF AMBIENT NOISE ON TAG READABILITY

Antennas at the test site were located near a frog and a rail joint. These track irregularities produced acoustic noise and vibration with each wheel passing, which adversely affected the readability of tags mounted in some locations. Thus, antennas should not be placed near such track discontinuities.

Note: Contact Thomas S. Guins (202) 639-2259 with questions or comments about this document.

DISCLAIMER: Preliminary results in this document are disseminated by the Association of American Railroads (AAR) for informational purposes only and are given to, and are accepted by, the recipient at the recipient's sole risk. The AAR makes no representation or warranties, either expressed or implied, with respect to this document or its contents. The AAR assumes no liability to anyone for special, collateral, exemplary, indirect, incidental, consequential, or any other kind of damages resulting from the use or application of this document or its contents. Any attempt to apply the information contained in this document is made at the recipient's own risk.